

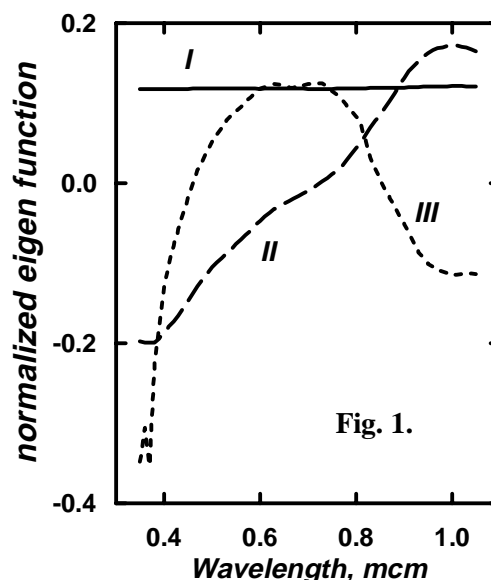
# ON POSSIBILITY TO ESTIMATE LUNAR SOIL MATURITY FROM RESULT OF STATISTICAL ANALYSIS OF SPECTRAL MEASUREMENTS. *D. G. Stankevich,*

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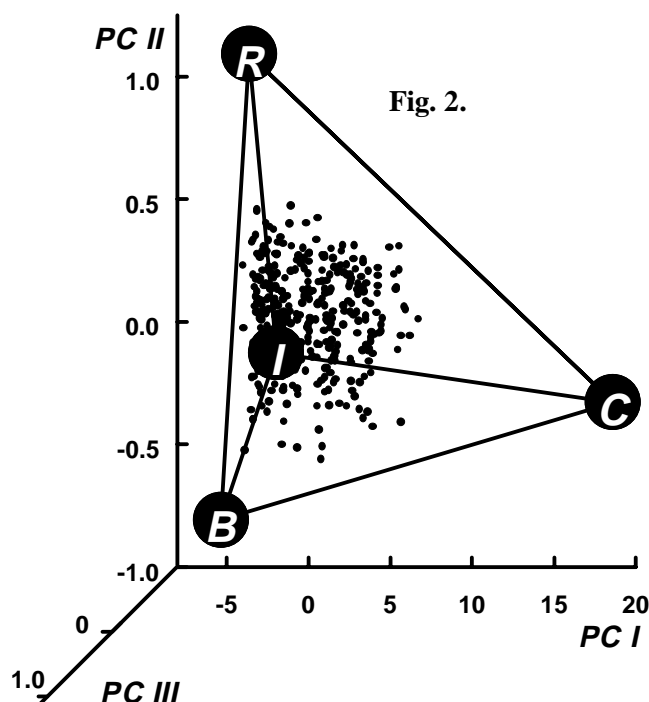
For reliable derivation of lunar regolith composition properties from reflectance spectra, data on regolith maturity are necessary. Spectra of the regolith samples of similar composition and different maturity differ in magnitude of spectral features. Immature soils display deeper absorption bands of pyroxenes and olivines and higher curvature of the spectrum in the visible range. [1]. Spectral feature magnitude of a whole spectrum is a qualitative attribute, however there is a way to measure it quantitatively and to correlate it with maturity of the lunar surface. To define the spectral feature magnitude quantitatively we used the method of principal components (PC). The method of PC means the presentation of the spectra as linear combinations of a set of eigen functions chosen so decreasing of the coefficients of the linear combinations with increasing of the function number is most rapid. [e.g., 2]. The coefficients of the linear combinations are called PC.

As source data for the present work we used spectra in the  $0.35 - 1.1 \mu$  range in logarithmic form from the catalog by C. Pieters [3] for 360 lunar sites. We calibrated the spectra using our photometric data [4].

Analysis with PC method revealed three eigen functions, whose superposition approximates all source spectra with an error within the accuracy of observations. These eigen functions turns out to have a simple interpretation (**Fig. 1**):



**Fig. 1.**



**Fig. 2.**

- I - is almost not changed in the whole spectral range and primarily bears information about albedo of the lunar site;
- II - is approximately linear in the whole spectral range and primarily characterizes the spectral slope in the visible range;
- III - determines degree of the UV descent of the spectrum and intensity of the  $0.95 \mu$  absorption band.

The latter eigen function is the one related to magnitude of the spectral features. Corresponding PC can serve as a quantitative measure of the magnitude. Note that a correlation in behavior of spectra in UV edge and the intensity of the  $0.95 \mu$  band is revealed by completely formal analysis by the PC method.

However on the lunar surface there is no sites whose spectra would be the same as the eigen functions. That is why it is a good idea to

SOIL MATURITY FROM SPECTRA: *D. G. Stankevich et al.*

search for some basic spectra that can be identified as more or less reasonable endmembers, so all lunar spectra can be expressed as a linear combination of the basic spectra.

In the PC space each spectrum is represented by a point. Our aim was to surround the cloud of the points representing all spectra from the catalog with the most simple polyhedron (in our three-dimensional case it is a tetrahedron). Its apices represent the desirable endmembers. A criterion for optimal choice of the tetrahedron is the most dense its filling with the cloud representing the catalog. The solution is shown in **Fig. 2**. The place of the found tetrahedron apices allows to interpret the chosen endmembers in the following way:

**B** - “blue mare” (low albedo, relatively small spectral slope);  
**R** - “red mare” (low albedo, relatively steep spectral slope);  
**I** - “immature mare” (low albedo, strong UV descent and deep 0.95  $\mu$  absorption band);  
**C** - “crater” (high albedo).

The basic spectra are shown in **Fig 3**. Now it is possible to present each spectrum  $F(\lambda)$  from the catalog in the following form:

$$F(\lambda) = rR(\lambda) + bB(\lambda) + iI(\lambda) + cC(\lambda)$$

where  $R, B, I, C$  are the basic spectra. Positive coefficients  $r, b, i, c$  ( $r + b + i + c = 1$ ) have a sense of quantities that classify spectra: if a coefficient is close to 1, it means that the spectrum is close to the corresponding endmember. As an illustration, **Fig. 4** shows spectra of two lunar sites: crater Cauchy and Rima Bode I. The former is supposed to be formed with immature soil; the latter is formed with mature soil. It is in agreement with our analysis: for crater Cauchy  $i = 0.657$ , while for Rima Bode I  $i = 0.033$ . (In **Fig. 4** triangles and rectangles show spectra from the catalog, lines show their approximations with PC method).

## References:

- [1] C. L. Marquardt and D. L. Griscom *The Moon* 15, 15-30, 1976.
- [2] R. Jaumann *J. Geophys Res* 96, 22793-22807, 1991.
- [3] C. M. Pieters. Lunar spectrophotometric catalogue. Brown Univ. 1990.
- [4] N. V. Opanasenko et al. *Solar System Res.*, 1996 (in press)

